How are non-caloric sweeteners related to energy intake and body weight?

Conclusion

Moderate evidence shows that using non-caloric sweeteners will affect energy intake only if they are substituted for higher calorie foods and beverages. A few observational studies reported that individuals who use non-caloric sweeteners are more likely to gain weight or be heavier. This does not mean that non-caloric sweeteners cause weight gain, rather that they are more likely to be consumed by overweight and obese individuals.

Grade: Moderate

Overall strength of the available supporting evidence: Strong; Moderate; Limited; Expert Opinion Only; Grade not assignable For additional information regarding how to interpret grades, click here.

Evidence Summary Overview

The Dietary Guidelines Advisory Committee (DGAC) answered this question using a partial Nutrition Evidence Library (NEL) review. The American Dietetic Association (ADA) Evidence Analysis Library (EAL) conducted a search from January 1985 through March 2006 on the question, “In adults, does using foods or beverages with non-nutritive sweeteners (saccharin, aspartame, acesulfame-K, sucralose, neotame) in a calorie-restricted or ad libitum diet affect energy balance?”

For adults, the conclusion was, “Using non-nutritive sweeteners in either a calorie-restricted or ad libitum diet will affect overall energy balance only if the non-nutritive sweeteners are substituted for higher calorie food and beverages (Grade II).” For children, they concluded, “Studies do not support that the use of non-nutritive sweeteners causes weight gain. If non-caloric beverages, including non-nutritive sweeteners, are substituted for sugar-sweetened beverages, there is a potential for energy savings in adolescents (Grade III).”

Additionally, ADA conducted a review of aspartame and body weight in 2008 that included articles reviewed in 2006. In this review, they asked the question, “In adults, does aspartame affect energy balance (weight)?” The conclusion was “Use of aspartame by individuals consuming a hypocaloric diet may be associated with increased weight loss. In some cases aspartame did not affect weight loss (Grade I).”

The ADA EAL review of non-nutritive sweeteners in both adults and children served as the foundation for this review. This conclusion also is based on review of one meta-analysis (de la Hunty et al, 2006), a randomized crossover study (Flood, 2007) and a prospective cohort study (Fowler et al, 2008) published since 2006.

The meta-analysis by de la Hunty et al (2006) supports a significant reduction in energy intakes with aspartame compared with all types of control diets except when aspartame was compared with non-sucrose controls such as water. For body weight, the analysis was conducted in three stages: 1) Used all weight outcomes including follow-up weights, (2) excluded studies in which the control group gained weight and (3) excluded follow-up periods. A significant reduction in weight was seen for all three analyses. The combined effect was approximately a 3% reduction in body weight. The authors concluded that using foods and drinks sweetened with aspartame instead of sucrose results in a significant reduction in both energy intakes and body weight. Further, using foods and drinks sweetened with aspartame instead of those sweetened with sucrose is an effective way to maintain and lose weight.

In a prospective cohort study, Fowler et al (2008) reported a significant positive dose-response relationship between baseline artificially sweetened beverage consumption and incidence of overweight/obesity, incidence of obesity and body mass index (BMI) change; however, this association does not establish causality.

Flood et al (2006) examined the impact of beverage type (cola, diet cola or water) and size (12 or 18 fluid ounces) on intake at an ad libitum lunch. Participants consumed significantly more energy at lunch when cola was provided vs. diet cola or water.

Evidence Summary Paragraphs

Meta-analysis

de la Hunty et al, 2006 (neutral quality), a meta-analysis, examined the effect of substituting sugar with either aspartame alone or aspartame in combination with other intense sweeteners on energy intake or body weight. Included studies were randomized controlled trials (RCTs) that examined the effect of substituting sugar with either aspartame alone or aspartame in combination with other intense sweeteners on energy intake (at least 24 hours) or body weight. A total of 16 studies were included and two meta-analyses were performed: 1) Energy intake as outcome (15 studies), and 2) body weight as outcome (nine studies). Interventions ranged from one day to 19 weeks (with follow-up for three years). Seven trials had interventions less than one week, and three had trials that lasted for 10 or 12 weeks. Most trials were with normal weight or overweight adults and three trials were with obese adults. Four trials used soft drinks as the only vehicle for aspartame; the other studies used a combination of commercially available foods and drinks sweetened with aspartame or a mixture of intense sweeteners. A significant reduction in energy intake was seen with aspartame compared with all types of control except when aspartame was compared with non-sucrose controls such as water. Parallel design studies that compared the effects of aspartame with sucrose had an overall effect size of 0.4 standardized difference (SD) which corresponded to a mean reduction of about 10% of energy intake. For body weight, the analysis was conducted in three stages: 1) Used all weight outcomes including follow-up weights, 2) excluded studies in which the control group gained weight and 3) excluded follow-up periods. A significant reduction in weight was seen for all three analyses. The combined effect figure was 0.2 SD, which corresponded to about a 3% reduction in body weight. The authors concluded that using foods and drinks sweetened with aspartame instead of sucrose results in small, but significant reductions in energy intakes and body weight. Further, using foods and drinks sweetened with aspartame instead of those sweetened with sucrose is an effective way to maintain and lose weight.

Primary Citations

Flood et al, 2006 (positive quality), a randomized crossover trial, examined the impact of increasing beverage portion size on beverage and food intake. A component of the study design was to compare beverage type (cola, diet cola or water). Participants were 33 adults (55% female; age 19 to 30 years) who consumed lunch in the laboratory once a week for six weeks, for a total of six test sessions. On each test day, a standard breakfast was served in order to ensure a consistent level of hunger across sessions. At each lunch, the same foods were served, but the beverage served was varied in type (cola, diet cola or water) and portion size (12 fl oz or 18 fl oz). The diet cola was sweetened with aspartame and provided 0 kcal per serving. The order of experimental conditions was randomized across subjects. At all meals, subjects could eat ad libitum from the amount of food and beverage that was served. All foods and beverages were weighed prior to being served to subjects, and reweighed after the subjects had finished eating, to determine the amount of food and beverage consumed. Increasing beverage portion size significantly increased the weight of beverage consumed, regardless of the type of beverage served ($P<0.05$). Food intake at lunch did not differ significantly by either type or portion size of the beverage served. When the energy from the caloric beverage was added to the energy from food, total energy intake at lunch was increased significantly ($P<0.001$) compared with non-caloric beverages. Therefore, even though subjects consumed considerably more energy from the caloric beverage than the non-caloric beverages, they did not compensate for this additional energy by reducing food intake. The authors concluded that when a caloric beverage was consumed with a meal, food intake was not reduced and energy from the beverage added on to energy from food, resulting in a significant increase in total energy consumed at a meal; further, replacing caloric beverages with low-calorie or non-caloric beverages can be an effective strategy for decreasing energy intake.

Fowler et al, 2008 (neutral quality), a prospective cohort study, examined the relationship between artificially sweetened beverage (ASB) consumption and long-term weight gain in 3,371 adults (age 25 to 64 years) from the San Antonio Heart Study. Height, weight and ASB consumption were measured at baseline and seven to eight years later. At baseline, weekly consumption of soft drinks, coffee and tea were estimated. Participants reporting soft drink use were asked whether they usually drank sugar-free sodas, regular sodas or similar amounts of each; their AS soda dose was calculated accordingly. For abstainers, AS soda dose was set equal to zero. “Usual” sweeteners for coffee and tea were ascertained, and AS dosage calculated accordingly (or set equal to zero for abstainers). Participants were also asked whether they “usually” used sugar or sugar substitutes. A significant positive dose–response relationship emerged between baseline ASB consumption and all outcome measures (incidence ofoverweight/obesity, incidence of obesity and BMI change), adjusted for baseline BMI and demographic and behavioral characteristics. Consuming more than 21 ASBs per week (vs. none) was associated with almost-doubled risk of OW and OB (OR=1.93; P=0.007) among 1,250 baseline normal weight (NW) individuals and doubled risk of obesity (OR=2.03; P=0.0005) among 2,571 individuals with baseline BMI of less than 30kg/m^2. Compared with non-users (+1.01kg/m^2), ΔBMIs were significantly higher for ASB quartiles two to four: +1.46 (P=0.003), +1.50 (P=0.002), and +1.78kg/m^2 ($P<0.0001$), respectively. Overall, adjusted ΔBMIs were 47% greater among AS users than nonusers (+1.48kg/m^2 vs. +1.01kg/m^2, respectively, $P<0.0001$). The authors concluded that they observed a positive dose-response relationship between ASB consumption and long-term weight gain. Further, they noted that the association does not establish causality but additional research is needed to evaluate the possible impact of AS use on the risk of obesity.

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Author, Year, Study Design, Class, Rating	Participants	Description of Study Methodology	Outcomes

de la Hunty A, Gibson S et al, 2006 Study Design: Meta-analysis or Systematic Review Class: M Rating:	Meta-analysis with energy intake as outcome = 15 studies. Meta-analysis with body weight as outcome = nine studies.	Included studies were RCTs that examined the effect of substituting sugar with either aspartame alone or aspartame in combination with other intense sweeteners on energy intake (at least 24 hours) or body weight. A total of 16 studies were included.	Interventions ranged from one day to 19 weeks (with follow-up for three years). Seven trials had interventions <one week and three had trials that lasted for 10 or 12 weeks. Most trials were with normal weight or overweight adults and three trials were with obese adults. Four trials used soft drinks as the only vehicle for aspartame; the other studies used a combination of commercially available foods and drinks sweetened with aspartame or a mixture of intense sweeteners. A significant ↓ in energy intake was seen with aspartame compared with all types of control except when aspartame was compared with non-sucrose controls such as water. Parallel design studies that compared the effects of aspartame with sucrose had an overall effect size of 0.4 SD, which corresponded to a mean ↓ of about 10% of energy intake. For body weight, the analysis was conducted in three stages: 1) Used all weight outcomes including follow-up weights 2) Excluded studies in which the control group ↑ weight 3) Excluded follow-up periods. A significant ↓ in weight was seen for all three analyses. The combined effect figure was 0.2 SD, which corresponded to about a 3% ↓ in body weight.

Flood JE, Roe LS et al, 2006 Study Design: Randomized Crossover Trial Class: A Rating: ⊕	Initial N=40 adults. Final N=33 adults (55% female). Age: 19 to 30 years. Location: United States.	Participants consumed lunch in the laboratory once a week for six weeks, for a total of six test sessions. On each test day, a standard breakfast was served in order to ensure a consistent level of hunger across sessions. At each lunch, the same foods were served, but the beverage served was varied in type (cola, diet cola or water) and portion size (12 fl oz or 18 fl oz). The diet cola was sweetened with aspartame and provided 0kcal per serving. The order of experimental conditions was randomized across subjects. At all meals, subjects could eat ad libitum from the amount of food and beverage that was served. All foods and beverages were weighed prior to being served to subjects and reweighed after the subjects had finished eating, to determine the amount of food and beverage consumed.	Increasing beverage portion size significantly ↑ the weight of beverage consumed, regardless of the type of beverage served ($P<0.05$). NS difference in food intake at lunch by either type or portion size of the beverage served. When the energy from the caloric beverage was added to the energy from food, total energy intake at lunch was ↑ significantly ($P<0.001$), compared with non-caloric beverages. Therefore, even though subjects consumed considerably more energy from the caloric beverage than the non-caloric beverages, they did not compensate for this additional energy by reducing food intake.

Fowler SP, Williams K et al, 2008 Study Design: Prospective Cohort Study Class: B Rating:	N=3,371 adults. Age: 25 to 64 years. San Antonio Heart Study. Location: United States.	Height, weight and artificially sweetened beverage (ASB) consumption were measured at baseline and seven to eight years later. At baseline, weekly consumption of soft drinks, coffee and tea were estimated. Participants reporting soft drink use were asked whether they usually drank sugar-free sodas, regular sodas or similar amounts of each; their AS soda dose was calculated accordingly. For abstainers, AS soda dose was set equal to zero. “Usual” sweeteners for coffee and tea were ascertained and AS dosage calculated accordingly (or set equal to zero for abstainers). Participants were also asked whether they “usually” used sugar or sugar substitutes.	A significant positive dose-response relationship emerged between baseline ASB consumption and all outcome measures (incidence of overweight/obesity, incidence of obesity and BMI change), adjusted for baseline BMI and demographic and behavioral characteristics. Consuming more than 21 ASBs per week (vs. none) was associated with almost-doubled risk of OW and OB (OR=1.93; P=0.007) among 1,250 baseline normal weight (NW) individuals, and doubled risk of obesity (OR=2.03; P=0.0005) among 2,571 individuals with baseline BMI <30kg/m^2. Compared with non-users (+1.01kg/m2), ΔBMIs were significantly higher for ASB quartiles two to four: +1.46 (P=0.003), +1.50 (P=0.002) and +1.78kg/m2 (P<0.0001), respectively. Overall, adjusted ΔBMIs were 47% greater among AS users than non-users (+1.48kg/m^2 vs. +1.01kg/m^2, respectively, P<0.0001).

Research Design and Implementation Rating Summary
For a summary of the Research Design and Implementation Rating results, click here.

Worksheets

de La Hunty A, Gibson S, Ashwell M. A review of the effectiveness of aspartame in helping with weight control. *Br Nutr Found Nutr Bull.* 2006: 31; 115-128.

Flood JE, Roe LS, Rolls BJ. The effect of increased beverage portion size on energy intake at a meal. *J Am Diet Assoc.* 2006 Dec; 106(12): 1,984-1,990.

Fowler SP, Williams K, Resendez RG, Hunt KJ, Hazuda HP, Stern MP. Fueling the obesity epidemic? Artificially sweetened beverage use and long-term weight gain. *Obesity* (Silver Spring). 2008 Aug; 16 (8): 1,894-1,900. Epub 2008 Jun 5.